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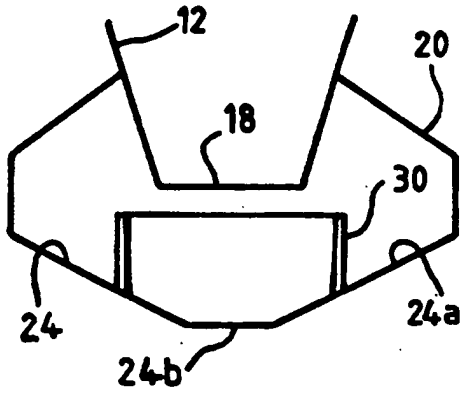
(54) Title: IMPROVED DUST SEPARATION APPARATUS

(57) Abstract

The invention provides apparatus (10) for separating dirt or dust from an airflow comprising a frustoconical cyclone (12) having a tangential air inlet (16) located at or adjacent the end of the cyclone (12) having the larger diameter and a cone opening (18) located at the end of the cyclone (12) having the smaller diameter. A collector (20) is arranged so as to surround the cone opening (18) and has a base surface (24) facing towards the cone opening (18). According to the invention, at least a portion (24a) of the base surface (24') is conical or frustoconical in shape and dust-retaining means (30) are provided spaced from the centre of the base surface. This allows the apparatus (10) to be reduced in size without substantially affecting the separation efficiency.



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IMPROVED DUST SEPARATION APPARATUS

The invention relates to apparatus for separating dirt or dust particles from an airflow by cyclonic means. The invention relates particularly, but not exclusively, to cyclonic dust separation apparatus for use in a vacuum cleaner.

Cyclonic dust separation apparatus typically comprises a frusto-conical cyclone having a tangential air inlet at the end having the larger diameter and a cone opening leading to a dirt or dust collector at the end having the smaller diameter. The dust collector is generally cylindrical in shape and is considerably larger in diameter than the cone opening, normally having a diameter of at least three times that of the cone opening. In operation, an airflow carrying dirt and dust with it enters the cyclone via the air inlet and, by virtue of the tangential orientation of the air inlet, is set into a swirling motion over the interior surface of the cyclone. Most of the air of the airflow escapes from the cyclone by passing towards the longitudinal axis of the cyclone and exiting via an exit passage arranged substantially centrally of the end of the cyclone having the larger diameter. The remainder of the airflow spirals towards the cone opening at

increasing angular speeds carrying the dirt and dust with it and is ejected into the dust collector, whereupon the dirt and dust particles are flung towards the cylindrical wall of the collector. The dirt and dust particles then collect in the lower regions of the cylindrical wall, whilst the remainder of the airflow exits from the collector via the cone opening and the exit passage.

It is generally desirable for cyclonic dust separation apparatus to be relatively compact, particularly as regards the overall length of the apparatus, ie, the dimension parallel to the longitudinal axis of the cyclone. If the apparatus is used in a vacuum cleaner, compact dust separation apparatus reduced the overall dimensions of the complete cleaner and lowers the centre of gravity of the cleaner which, in turn, increases its stability. This is particularly advantageous in cylinder-type cleaners as well as upright-type vacuum cleaners.

It is an object of the present invention to provide dust separation apparatus which is relatively compact without any significant loss of dust separation efficiency.

According to the invention, there is provided apparatus as claimed in claim 1. Advantageous features are set out in the subsidiary claims.

Dust separation apparatus of the type mentioned at

the outset is often required to be located at an angle to a fixed surface. In the case of an upright-type vacuum cleaner, which is restricted in its overall height for practical reasons, the body of the cleaner containing the dust separation apparatus is tilted in use with respect to the cleaner head so as to facilitate the movement of the cleaner head over the surface to be cleaned. Also, in cylinder-type vacuum cleaners, it is advantageous to position the centre of gravity as close as possible to the surface to be cleaned and this can be assisted by tilting the dust separation apparatus with respect to the said surface. It has been known to provide a collector having a base surface with a conical or frusto-conical portion. This allows the apparatus to be tilted without the need to raise the apparatus in the first place. The provision of a conical- or frustoconical-based collector had previously been dismissed as impractical because it was thought that separated dirt and dust would collect closer to the cone opening than in the standard flat-based collector, which would encourage separated dirt and dust to become re-entrained in the airflow. It has since been found that this is not the case and the separation efficiency of a conical- or frustoconical-based collector is very similar to that of a corresponding flat-based collector. However, the provision of dust-retaining means spaced from the centre of the conical- or

frustoconical-based collector in accordance with the second aspect of the invention further improves the separation efficiency of the apparatus.

Embodiments of the invention will now be described with reference to the accompanying drawings, wherein:

Figure 1 is a sectional side view of known apparatus for separating dirt or dust from an airflow;

Figure 2 is a sectional side view, corresponding to part of Figure 1, of a first embodiment of the present invention; and

Figure 3 is a sectional side view, corresponding to Figure 1, of a second embodiment of the invention.

Figure 1 shows known apparatus 10 for separating dirt or dust from an airflow consisting of a frustoconical cyclone 12 having an interior surface 14. An air inlet 16 is arranged at the end of the cyclone 12 having the larger diameter and the air inlet 16 communicates with the cyclone 12 so as to introduce air tangentially into the cyclone 12.

At the end of the cyclone 12 having the smaller diameter, ie. remote from the air inlet 16, there is a cone opening 18. Surrounding the cone opening 18 and sealed against the outer walls of the cyclone 12 is a collector 20 for collecting dirt and dust separated from the airflow. The main body of the collector 20 is generally cylindrical in shape although inclined walls 22 extend between the generally cylindrical portion and

the cyclone 12. The collector 20 has a base surface 24 facing towards the cone opening 18, ie. remote from the main body of the cyclone 12.

In use, an airflow consisting of a stream of air having dirt and dust particles entrained therein enters the cyclone 12 via the inlet 16. Because of the tangential entry arrangement, the dirt-laden airflow takes up a swirling motion inside the cyclone 12 and spirals over the interior surface 14 of the cyclone 12 towards the cone opening 18 at ever-increasing angular speeds, with clean air escaping from the cyclone 12 by moving inwardly towards the longitudinal axis and upwardly towards an exit port 17. As soon as the remainder of the airflow enters the collector 20 via the cone opening 18, the dirt and dust particles entrained within the airflow are flung towards the side walls of the collector 20. The airflow, which is substantially free of dirt and dust particles, then exits the collector 20 via the cone opening 18 and leaves the cyclone 12 by means of the exit port 17 located substantially centrally of the end of the cyclone 12 having the larger diameter.

Figures 2 and 3 illustrate the invention which provides an additional measure designed to reduce any possibility of dirt and dust collected in the collector 20 becoming re-entrained in the airflow circulating in the apparatus 10. This measure applies primarily in

cases wherein the distance between the cone opening 18 and the base surface 24 is less than 8mm or wherein the base surface 24 is conical or frusto-conical in shape.

In order to reduce the possibility of dirt and dust located in the collector 20 from being re-entrained into the airflow, dirt and dust-retaining means in the form of a wall 30 are provided on the base surface 24. The wall 30 is upwardly extending with respect to the base surface 24 and is substantially annular in shape, although other plan shapes could be utilised. The diameter d of the annular wall 30 is substantially 70mm but this could be varied within the range 30mm to 100mm. The height w of the wall 30 is substantially 55mm from the junction between the wall 30 and the base surface 24 but could be varied within the range 20mm to 60mm.

The wall 30 has a tapering cross-section as shown in Figure 2. The thickness of the wall 30 is greater at the end thereof adjacent the junction with the base surface 24 than at the distal end. The upper end of the wall 30 is radiused to form a smooth finish.

When the annular wall 30 is provided in conjunction with a frustoconical base surface 24 as shown in Figure 3, the junction between the wall 30 and the base surface 24 is on the frustoconical portion 24a of the base surface 24. However, if the central portion 24b is sufficiently large in diameter, the junction between the

wall 30 and the base surface 24 can occur in the central planar portion 24b.

In operation, air exiting the cyclone 12 via the cone opening 18 causes dirt and dust particles entrained therein to be flung against the outer walls of the collector 20. The annular wall 30 prevents the dirt and dust particles from travelling towards the central portion of the base surface 24 and thereby reduces the possibility of dirt and dust particles becoming re-entrained into the airflow.

It is envisaged that cyclonic dust separation apparatus as described above can be used to advantage in a number of different situations. The application to which it is envisaged that the present invention is most likely to be applied is that of vacuum cleaning apparatus. Either of the aspects of the invention described above can be used in an upright or cylinder-type vacuum cleaner in order to lower the centre of gravity and/or reduce the size of the apparatus as a whole. It is also likely that the apparatus described above will be used in conjunction with further cyclonic dust separation apparatus specifically designed to remove larger dust and fluff particles in a so-called "low efficiency" cyclone. The apparatus described above will therefore be intended to remove only the finer particles of dirt and dust entrained in the airflow.

However, it is also envisaged that the invention described above may well be utilised in other situations, for example the removal or dirt and dust particles from internal combustion engine emissions. The principles described above are equally applicable to such situations and need not be used in combination with further cyclonic separation apparatus unless it is so desired.

CLAIMS

1. Apparatus for separating dirt or dust from an airflow comprising a frustoconical cyclone having a tangential air inlet located at or adjacent the end of the cyclone having the larger diameter and a cone opening located at the end of the cyclone having the smaller diameter, and a collector arranged so as to surround the cone opening and having a base surface facing towards the cone opening, at least a portion of the base surface being conical or frustoconical in shape, wherein the base surface comprises dust-retaining means spaced from the centre thereof.

2. Apparatus as claimed in claim 1, wherein the dust-retaining means comprise an upwardly-extending annular wall.

3. Apparatus as claimed in claim 2, wherein the wall extends upwardly from the junction thereof with the base surface for between 10mm and 60mm.

4. Apparatus as claimed in claim 3, wherein the wall extends upwardly from the junction thereof with the base surface for substantially 55mm.

5. Apparatus as claimed in any one of claims 2 to 4,

wherein the diameter of the wall is between 30mm and 100mm.

6. Apparatus as claimed in claim 5, wherein the diameter of the wall is substantially 70mm.

7. Apparatus as claimed in any one of claims 2 to 6, wherein the thickness of the wall is greater at the end adjacent the junction with the base surface than at the end remote therefrom.

8. Apparatus as claimed in any one of claims 2 to 7, wherein the end of the wall remote from the junction with the base surface is radiused.

9. Apparatus as claimed in any one of claims 1 to 8, wherein the base surface comprises a frustoconical portion and a circular portion.

10. Apparatus as claimed in claim 9, wherein the diameter of the circular portion is substantially the same as that of the cone opening.

11. Apparatus as claimed in claim 9 or 10, wherein the diameter of the circular portion is between 20mm and 30mm.

12. Apparatus as claimed in claim 9, wherein the diameter of the circular portion is substantially 25mm.

13. Apparatus as claimed in claim 9, wherein the diameter of the circular portion is substantially greater than that of the cone opening.

14. Apparatus as claimed in claim 13, wherein the diameter of the circular portion is substantially 125mm.

15. Apparatus as claimed in any one of claims 9 to 14, wherein the circular portion is planar.

16. Apparatus as claimed in any one of claims 1 to 15, wherein the conical or frusto-conical portion of the base surface is inclined at an angle of between 30° and 50° to the longitudinal axis of the cyclone.

17. Apparatus as claimed in claim 16, wherein the conical or frusto-conical portion of the base surface is inclined at an angle of substantially 40° to the longitudinal axis of the cyclone.

18. Apparatus for separating dirt or dust from an airflow substantially as hereinbefore described with reference to any one of the embodiments shown in the accompanying drawings.

19. A vacuum cleaner incorporating apparatus according to any one of the preceding claims.

20. A vacuum cleaner as claimed in claim 19, further comprising further apparatus for separating dirt or dust from the airflow, the said further apparatus being positioned upstream of the said apparatus.

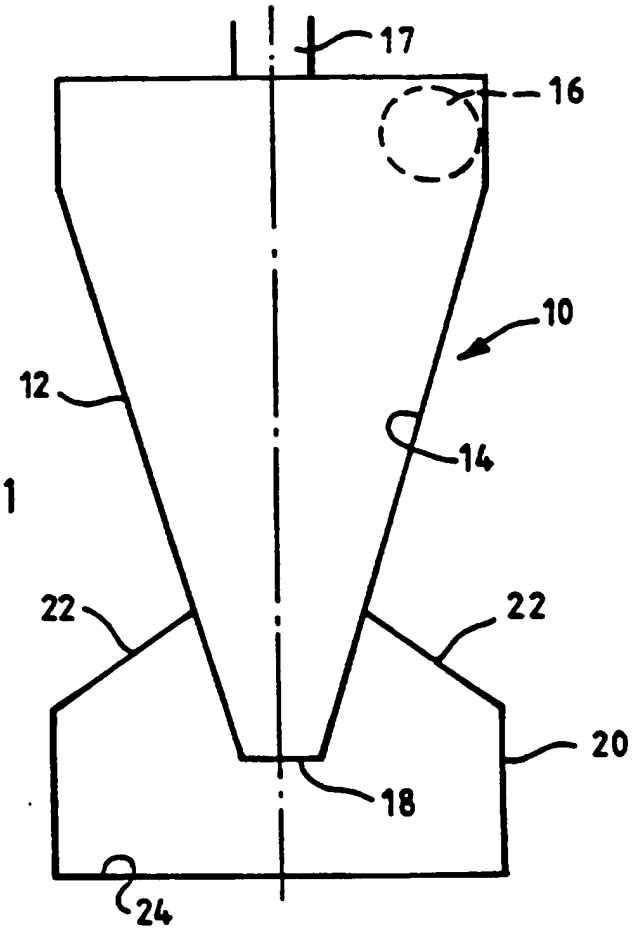


FIG.1

FIG.2

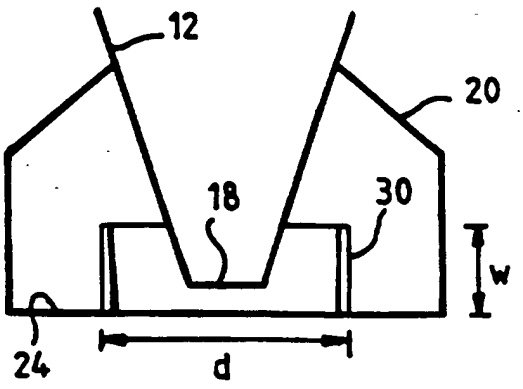
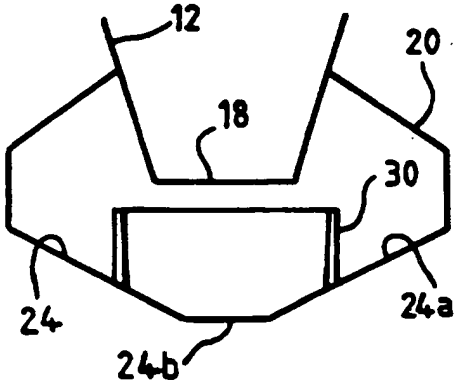


FIG.3



INTERNATIONAL SEARCH REPORT

Intn. nal Application No
PCT/GB 95/02986

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 B04C5/185 A47L9/16

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 B04C A47L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP,A,0 068 792 (QUEEN'S UNIVERSITY AT KINGSTON) 5 January 1983 see page 1, line 1 - line 11 see page 8, line 21 - page 9, line 18 see page 17, line 3 - page 18, line 14; figures 1-4,14	1,9,16, 17
Y	---	19,20
Y	US,A,5 090 976 (DYSON) 25 February 1992 see column 3, line 27 - column 5, line 13; figures	19,20
A	---	1,15
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Date of the actual completion of the international search	Date of mailing of the international search report
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Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US,A,3 802 570 (DEHNE) 9 April 1974 see column 1, line 33 - line 53 see column 3, line 49 - column 4, line 23 see column 4, line 60 - column 5, line 7; figures ---	1,2,9, 15,16
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